Stress Testing the Canadian Banking System: A System-Wide Approach

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- Stress testing is an important tool for evaluating risks to the financial system. The models used to conduct these tests are evolving to include more realistic features.
- The 2007–09 financial crisis demonstrated that, in addition to solvency risk, liquidity risk and spillover effects can generate losses for banks during times of stress. The Bank of Canada has developed an innovative stress-testing model—the MacroFinancial Risk Assessment Framework (MFRAF)—which captures the various sources of risk (solvency, liquidity and spillover effects) that banks face.
- We apply MFRAF to the stress-testing scenario used in the 2013 Canada Financial Sector Assessment Program led by the International Monetary Fund. We show that the aggregate capital position of Canadian banks is 20 per cent lower when liquidity and spillover risks are added to solvency risk. Nevertheless, the results still confirm the overall strength of the Canadian banking system.

Introduction

Over the past few years, financial sector authorities and financial institutions around the world have increased their use of stress testing to examine risks to the financial system. Stress testing assesses the impact of various potential risks to financial institutions and illustrates the channels through which these risks would be transmitted. While most stress-testing models focus on solvency risk (the risk of losses stemming from the failure of borrowers to repay loans or meet contractual obligations), the 2007–09 financial crisis showed that, in times of stress, liquidity risk and network spillover effects associated with interconnections among banks can also be significant. The Bank of Canada has developed an innovative stress-testing model, the MacroFinancial Risk Assessment Framework (MFRAF), which realistically captures the various sources of risk for banks—solvency risk, liquidity risk and spillover effects.

In 2013, Canada participated in a Financial Sector Assessment Program (FSAP), a comprehensive, in-depth analysis of the country's financial sector conducted by the International Monetary Fund (IMF) that included a stress-testing exercise to gauge the resilience of financial institutions to severe macrofinancial stress.[1] The FSAP stress scenario embodied the realization of two key risks to the Canadian financial system that had been identified in previous issues of the *Financial System Review*: (i) weaknesses in euro-area banks and sovereigns, and (ii) imbalances in Canadian household finances and the housing market. Several stress-testing approaches and models, including MFRAF, were used to estimate the impact of these risks on the Canadian banking system should they be realized. Overall, the results confirm the strength of the Canadian banking system as a whole, and the IMF views the resulting capital shortfall as manageable.

The results obtained with MFRAF show that, when liquidity risk and spillover effects are considered in addition to solvency risk, the aggregate capital position of banks declines by an additional 20 per cent.[2] This finding highlights the importance of a comprehensive approach to stress testing. As well, it creates an incentive for the Bank of Canada to further enhance MFRAF to improve its understanding of the potential effects of a severe stress scenario on the Canadian banking system.

The following three sections: (i) define stress testing and how it is used to assess risks; (ii) describe MFRAF; and (iii) present the results obtained with MFRAF in the context of the 2013 FSAP. The final section concludes with remarks on the direction of future research.

1 For the conclusions of the 2013 Canada FSAP, see IMF (2014).

2 The IMF views MFRAF as being "at the frontiers of systemic risk stress testing." See IMF (2014), page 54.

Table 1: **Stress testing: Comparing models and approaches**

	Bottom-up stress test	Top-down stress test	
Key features	**Run by individual banks**	**Run by authorities**	
Testing for	Solvency risk	Solvency risk	MFRAF: solvency risk, liquidity risk and spillover effects
Strengths	▪ Bank models capture a large amount of detailed data on their portfolios and exposures, which provide information on the specific drivers of their stress-testing results. ▪ Banks have different business models and exposures to risks: their stress-testing models capture these idiosyncrasies.	▪ Authorities use a common model to generate results for different banks, enabling comparison of the results across banks to better understand their respective vulnerabilities to specific shocks. ▪ Tests are usually applied on a bank-by-bank basis, but results can be aggregated to determine the "typical" impact of specific stress scenarios on the banking sector.	▪ Sources of risks affecting banks are taken into account in a consistent manner. ▪ Tests are applied on a bank-by-bank basis, but interactions between banks are captured. ▪ The framework can be used as a pure top-down model or as a "hybrid," with inputs from a bottom-up stress test.
Limitations	▪ Interactions with other banks during periods of stress and related network effects are not accounted for. ▪ Liquidity risk is not explicitly captured (beyond the effects of rising funding costs in times of stress).	▪ Tests provide fewer details regarding the drivers of results than in a bottom-up stress test. ▪ Tests use simple models based on observed historical relationships between key macrofinancial variables and banks' indicators, making it more difficult to capture the idiosyncrasies of individual banks. ▪ Liquidity risk is not explicitly captured (beyond the effects of rising funding costs in times of stress). ▪ Interactions between banks are not explicitly taken into account; hence, there are no spillover effects.	▪ Tests provide fewer details on drivers of results than bottom-up stress tests. ▪ This approach requires large amounts of detailed balance-sheet data.

Source: Bank of Canada

Stress Testing: Definition, Uses and Components

Stress testing is a tool used by banks for purposes of internal risk management and by authorities to quantify the impacts that large but plausible negative shocks could have on the capital positions of banks (BCBS 2009). Stress tests do not take into account corrective management actions such as raising additional capital and implementing cost-cutting measures, which banks would typically take if such conditions were to materialize.[3] In this sense, stress tests evaluate extreme outcomes.

There are two main approaches to conducting stress tests. In *bottom-up* stress tests, individual banks use their internal models. In *top-down* stress tests, regulatory authorities apply their own models. The chief advantage of a bottom-up stress test is that, since banks' internal models capture each institution's idiosyncrasies, it is possible to better understand the specific drivers of the results for individual banks. In contrast, the main advantage of a top-down stress test is that, by using a common model for different banks, authorities can compare the results across banks to obtain insights regarding their respective vulnerabilities to the same shocks. However, weaknesses are also evident in both approaches. It can be more difficult, for example, to take into account the interactions between banks in a bottom-up stress test, while top-down tests tend to capture the characteristics of banks in less detail.

Table 1 summarizes the key strengths and limitations of the various stress-testing approaches.

Stress testing is being used more frequently by authorities around the world, but in different ways. In some jurisdictions, the focus is on the stress-testing results for individual banks. For example:

- In the United States, the Federal Reserve evaluates plans by large banks to make capital distributions and approves these plans only for institutions that demonstrate sufficient financial strength under a severe stress scenario.[4]

3 Management responses to financial stresses are part of the recovery plans that systemically important financial institutions are expected to design as part of the G-20 regulatory reform agenda. In Canada, the Big Six banks have been designated as domestic systemically important banks (D-SIBs) by the Office of the Superintendent of Financial Institutions and, consequently, are required to develop recovery and resolution plans. D-SIBs are required to hold a 1 per cent common equity surcharge starting in 2016 (i.e., they will be required to meet an 8 per cent CET1 ratio). See OSFI (2013a).

4 For example, in 2014, the Federal Reserve objected to the plans of five of the 30 participating banks. For details, see http://www.federalreserve.gov/newsevents/press/bcreg/20140326a.htm.

- In Europe, authorities have used stress tests to evaluate the resilience of individual European banks and to assess their recapitalization needs under stressed conditions. Before assuming its supervisory role in November 2014, the European Central Bank (ECB) will conduct and publish a stress test as part of its comprehensive assessment in order to rebuild investor confidence in the European banking sector.

In other jurisdictions, e.g., Sweden and Norway, authorities use stress tests to better understand how the banking sector would be affected by adverse macroeconomic developments (Sveriges Riksbank 2012; Norges Bank 2013). In Canada, stress testing is part of the tool kit used to assess risks for individual banks and for the banking sector as a whole. The Office of the Superintendent of Financial Institutions (OSFI) promotes internal stress testing as an important tool for banks to use in making decisions related to business strategy, risk management and capital management.[5] In this context, OSFI reviews institutions' stress-testing programs as part of its supervisory review process and its review of the internal capital-adequacy assessment process for deposit-taking institutions. Moreover, OSFI and the Bank of Canada conduct an annual joint exercise to stress test the major Canadian banks to identify system-wide vulnerabilities that could materialize under adverse macrofinancial conditions, and use the results to inform assessments of risk for the financial system as a whole.[6] This joint exercise is a bottom-up stress test: although the stress scenario and detailed instructions for applying the stress test are designed by the authorities, the banks use their internal models to calculate the impact of the stress scenario on their capital positions. The authorities analyze and compare the results provided by individual banks to determine the effects of the stress scenario on the entire banking sector, with a particular focus on understanding key drivers and the channels for the transmission of shocks.

Most stress-testing models, whether top-down or bottom-up, focus primarily on solvency risk.[7] However, as the financial crisis demonstrated, banks can be significantly affected by two other sources of risk during periods of stress: liquidity risk and spillover effects. *Liquidity risk* results from the combination of funding-liquidity risk (the risk that individual banks are unable to roll over existing funding or to obtain new funding) and market liquidity conditions (the conditions under which banks can sell and repurchase, or sell outright, assets in financial markets to meet their funding needs). During the financial crisis, interactions between funding liquidity and market liquidity created liquidity spirals, which particularly impacted institutions that relied heavily on wholesale funding and held highly illiquid assets (e.g., Northern Rock and Bear Stearns), ultimately affecting global financial stability.[8] *Network spillover effects* occur when a bank is unable to fulfill its obligations to other banks, creating counterparty credit losses for those banks (e.g., the banks exposed to Lehman Brothers when it defaulted in September 2008).

In addition to accounting for solvency risk, MFRAF also incorporates liquidity risk and network spillover effects.[9]

MFRAF: Model Description

MFRAF consists of three distinct, but interdependent, modules that account for the three different risks that banks face.[10] **Figure 1** shows how these risks could materialize over a one-year horizon following a risk event—for example, a severe macroeconomic shock—and how they contribute to an aggregate decline in the capital positions of banks. This decline is measured by determining the banks' common equity Tier 1 (CET1) capital ratio, as follows.[11] First, banks' balance sheets are affected by credit losses due to corporate and household defaults six months into the first year (the interim date) and again at the end of the first year. Second, if investors have concerns about a bank's future solvency and/or its liquidity position, liquidity risk materializes at the interim date, potentially generating additional losses. Finally, at the end of the period, some banks may be unable to repay their interbank counterparties, given the solvency and/or liquidity losses that they have incurred, which leads to network spillover effects. MFRAF considers each bank individually but takes into account the interactions between banks through both liquidity and interbank exposures.

Overall, the three risks contribute to a decline in the capital positions of banks. By decomposing the decline in CET1 ratios into their solvency, liquidity and network

5 For details, see OSFI (2009).

6 This regular stress-testing exercise was implemented following a recommendation by the IMF during Canada's 2007 FSAP.

7 Nevertheless, a range of market risks (including funding liquidity) that are consistent with the stress scenario tend to be indirectly captured by these models. For example, when the stress scenario incorporates conditions of scarce funding liquidity and declining asset prices, the former would lead to rising funding costs and interest expenses for banks and the latter to mark-to-market losses on securities available for sale. These effects would ultimately influence banks' capital positions.

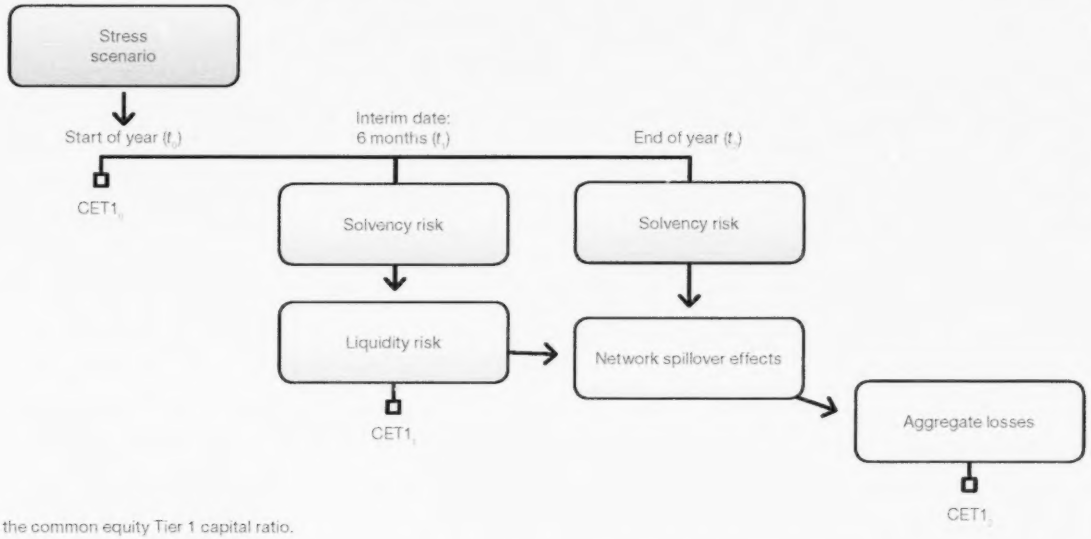
8 See, among others, Brunnermeier (2009) and Brunnermeier and Pedersen (2009). The Basel III liquidity framework was introduced to address the failures in liquidity-risk management that were exposed by the financial crisis. See Gomes and Wilkins (2013).

9 A number of other central banks (e.g., the Bank of England, the ECB and the Bank of Korea) are also developing stress-testing models that capture risks beyond solvency, although their methodologies differ.

10 See Appendix A for a more detailed description of the model and its calibration.

11 The CET1 ratio is equal to common equity (the highest-quality capital) divided by total risk-weighted assets.

Figure 1: MFRAF: A modular approach to systemic risk



Note: CET1 is the common equity Tier 1 capital ratio.
Source: Bank of Canada

components, MFRAF contributes to a better understanding of the various determinants of risk for banks and the channels through which shocks would propagate.

Solvency-risk module

In MFRAF's solvency-risk module, banks' balance sheets are affected by credit losses that result from the failure of non-bank borrowers to repay their loans or to meet their contractual obligations under stress. For each bank, we derive a distribution of expected annual credit losses that takes into account the historical correlations of defaults across sectors, together with the loss-given-default rates and exposures at default to the different sectors to which banks lend.[12]

Liquidity-risk module

In MFRAF, banks can be affected by liquidity risk, either directly, through the funding decisions of their creditors, or indirectly, through information contagion. Both of these dynamics were observed during the financial crisis. Liquidity risk can materialize *endogenously* as a result of solvency risk and the liquidity characteristics of banks (reliance on unstable funding and/or low holdings of liquid assets). Following the realization of credit losses at the interim (six-month) date (**Figure 1**), the creditors of each bank must decide whether or not to roll over their funding to the bank (i.e., whether to "run"). This decision depends on two elements: (i) creditors' concerns over the future solvency of the bank (which depends on the severity of the losses incurred by the end of the year and the bank's starting capital position) and (ii) the bank's liquidity characteristics.

Creditors assess a bank's solvency relative to a certain threshold (typically a supervisory threshold).[13] In such assessments, they compare the value of the bank's liquid and illiquid assets with its liabilities that are susceptible to a run at the interim date. If the value of the liquid and illiquid assets is greater than the stock of liabilities susceptible to a run, the creditor judges that the bank has more than enough liquidity to meet the demands of all its creditors, and funding will be rolled over. If the reverse is true, there is a positive probability of a run; this probability is determined as the outcome of a coordination game.[14] When liquidity risk materializes, banks experience additional losses.[15]

12 The sectors include households (uninsured residential mortgages, home equity lines of credit and consumer loans), businesses (manufacturing, construction, accommodations, commercial real estate, agriculture, wholesale, financial institutions and small business loans) and governments.

13 For the FSAP, we assumed that creditors have concerns about solvency when a bank's future CET1 ratio falls below OSFI's supervisory threshold of 7 per cent. It is important to note that falling under 7 per cent is not equivalent to failure: the threshold for the Basel III regulatory CET1 ratio is 4.5 per cent.

14 A coordination game is a situation in which agents realize gains when they all take the same action but make their decisions independently and are uncertain about the actions of other agents. In this coordination game, creditors compare the expected returns from running on the bank versus rolling over their claims. For an individual creditor, the return from rolling over its claims depends on the share of other creditors that also roll over their claims. In contrast, a creditor that decides to run obtains a fixed return (from investing instead in a risk-free asset).

15 For the FSAP, the liquidity losses were calibrated at 2.25 per cent of risk-weighted assets.

Liquidity risk can also materialize because of information contagion, i.e., the risk that creditors will run on a bank with a sound balance sheet after observing the CET1 ratio of one or more other banks decline below 7 per cent.[16] In this context, a bank's creditors update their beliefs regarding market liquidity conditions. In some instances, creditors may become more pessimistic, which leads them to have a less favourable view of the liquidity characteristics of their own bank and influences their decision on whether to extend funding. If the new-found pessimism is widespread, it may result in contagious runs such as those observed during the financial crisis.

The endogenous materialization of liquidity risk resulting from the interactions between solvency, funding and market-liquidity risk is a feature of MFRAF that sets it apart from other stress-testing models.

Network spillover effects

Following the realization of credit and liquidity losses, some banks may be unable to repay their full obligations to other banks. We consider interbank exposures to be subordinate to other debt, i.e., banks first settle other debt obligations before turning to their interbank counterparties.[17]

Application of MFRAF in the 2013 FSAP

FSAP stress scenario

The stress scenario used in the 2013 FSAP includes the materialization of the key risks identified in the *Financial System Review*, which could arise from two areas: (i) weaknesses in euro-area banks and sovereigns, and (ii) imbalances in Canadian household finances and the housing market.[18] The stress scenario covered the five-year period from 2013 to 2017.

The stress scenario begins with a disorderly default in a peripheral euro-area country, which results in a severe and persistent economic recession and a renewed banking crisis in the euro area. This leads to a general retrenchment from risk in the global financial system and significant disruptions in global bank funding markets, causing important adverse confidence and wealth effects and a weakening global economy. The Canadian economy faces financial headwinds, a large negative foreign demand shock, falling commodity prices, rising uncertainty, and unfavourable effects on confidence and wealth that affect both businesses and households, leading to a sharp decline in domestic demand. Business investment and consumer spending decrease significantly. As Canadian households face negative wealth shocks, tighter lending standards, deteriorating employment prospects and heightened uncertainty, they significantly reduce their expenditures on consumption and residential investment. In this environment, house prices decline markedly. Consequently, Canada faces a severe and persistent recession.[19] As shown in **Table 2**, the recession in the FSAP stress scenario is much more severe than any recession experienced by Canada over the past three decades.

Stress-test results

Overview

Four approaches were used in the FSAP to assess the impact of this stress scenario on Canadian banks: (i) a bottom-up solvency stress test conducted by the Big Six Canadian banks; (ii) a top-down solvency stress test conducted by OSFI; (iii) a top-down solvency stress test conducted by the IMF; and (iv) MFRAF, which was used as a "hybrid" model to complement the banks' bottom-up solvency stress test by capturing the impact of liquidity risk and network spillover effects.[20, 21] In all four approaches, banks were not allowed to include any

Table 2: **Key macroeconomic variables in the Financial Stability Assessment Program stress scenario**

Macroeconomic variables	2013 FSAP	2007–09 recession	1990s recession	1980s recession
Real GDP contraction (peak to trough, per cent)	-5.9	-4.2	-3.4	-5.1
Duration of recession (number of consecutive quarters of negative growth)	9	3	4	6
Peak increase in unemployment rate (percentage points)	5.9	2.4	4.1	5.8
House price correction (peak to trough, per cent)	-33.0	-7.6	-10.1	-4.2

Source: Bank of Canada

16 Information contagion is a recent innovation in MFRAF. Its inclusion enhances the model's ability to capture an important transmission mechanism observed during the crisis. For details, see Anand, Gauthier and Souissi (2014).

17 To clear the interbank network, MFRAF uses the algorithm of Eisenberg and Noe (2001), in which banks repay their interbank counterparties a sum that is proportional to the amounts originally due, causing counterparty credit losses.

18 Note that this scenario was generated in early 2013 and was based on the level of risks observed at that time. Since then, those risks have declined.

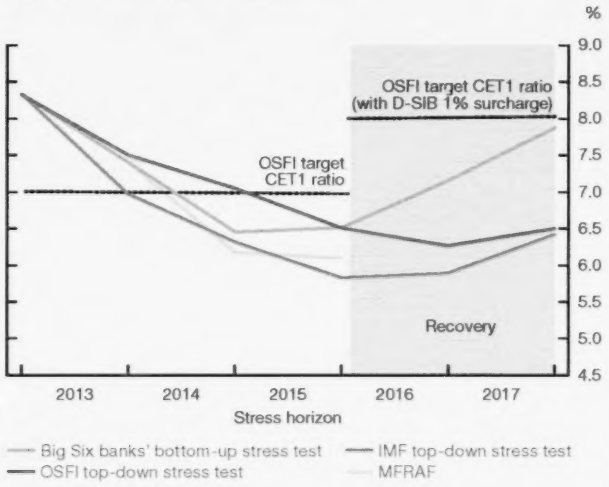
19 In this scenario, there is no liquidity injection by the central bank or extraordinary monetary policy stimulus.

20 For more information on the features of the various models and detailed results, see IMF (2014).

21 In practice, using MFRAF as a hybrid to augment the bottom-up stress test means that various outputs provided by the banks in the bottom-up stress test are used as inputs for MFRAF.

Chart 1: Results of the IMF Financial Sector Assessment Program stress test

Aggregate CET1 ratio for the Big Six banks



Note: CET1 is the common equity Tier 1 capital ratio.

Sources: Bank of Canada, International Monetary Fund, Office of the Superintendent of Financial Institutions and major banks

corrective management actions, except for the Basel III capital conservation buffer, which dictates restrictions on capital distribution, depending on the level of the CET1 ratio.[22, 23]

Chart 1 shows the dynamics of the aggregate CET1 ratio for the Big Six banks over the stress horizon under each of the four approaches. Although the bottom-up stress test and the OSFI and IMF top-down stress tests capture the impact of solvency risk, there are some differences in the results, which primarily reflect differences in modelling. Overall, under this stress scenario, solvency risk results in a decline of 170 to 250 basis points (from 8.33 per cent) in the aggregate CET1 ratio of banks. Although this is a large decline, it is not surprising, given the extreme severity of the stress scenario and the exclusion of corrective management actions from the exercise. Moreover, despite the severity of the scenario used, in Canada's 2013 FSAP, Canadian banks maintain a solid ability to generate capital, which is consistent with their past experience in times of stress. As outlined in its report, the IMF views the resulting capital shortfall in the FSAP stress scenario as manageable, emphasizing the overall resilience of the Canadian banking system.

The value added by MFRAF

The difference between the results obtained in the bottom-up stress test and those obtained with MFRAF stems from the marginal impact of liquidity risk and network spillover effects. Liquidity risk and network effects lead to an additional 40-basis-point decline in the aggregate CET1 ratio beyond the effect of solvency risk. Liquidity risk explains 65 per cent of this additional decline, and network effects account for the remaining 35 per cent.[24]

These results illustrate the importance of liquidity risk and network spillover effects in times of stress: they add almost 20 per cent to the estimated impact of this stress scenario on banks. It is therefore important for authorities to account for these effects when assessing the potential impact of stress scenarios on the banking system.

Conclusion

Stress testing is an important component of the tool kit available to authorities, including the Bank of Canada, to assess risks to the financial system. However, it is important to highlight that, despite recent significant progress in the development of stress-testing models, stress testing remains challenging because it attempts to capture the effects of tail events.

In most stress tests, solvency risk explains a large share of the deterioration in the capital ratios of banks during periods of severe stress. As demonstrated by the recent financial crisis, however, liquidity risk and network spillover effects can generate substantial additional losses for banks. Hence, it is important to take them into account when assessing risks. To this end, the Bank of Canada has developed an innovative stress-testing model, the MacroFinancial Risk Assessment Framework (MFRAF), which incorporates various sources of risk for banks—solvency risk, liquidity risk and spillover effects.

Research is ongoing to improve MFRAF in two directions. First, the liquidity module could be enhanced by developing a model to link the evolution of market liquidity conditions with the behaviour of banks under stress (e.g., their decision to sell liquid or illiquid assets to meet their funding needs). Second, MFRAF should incorporate a model of risk-weighted assets to more accurately estimate the effects of solvency risk, liquidity risk and network effects on bank capital levels.

22 See the report by Chouinard and Paulin in this issue on pages 53–59.

23 MFRAF was run for only the second and third years of the stress horizon because those years were the worst period of the stress scenario in terms of real growth and financial market conditions.

24 Network effects have a limited impact because the big banks have relatively small interbank exposures, owing to the extensive use of collateralization and hedging.

Appendix A

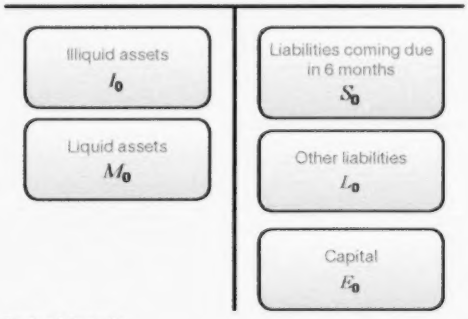
The MacroFinancial Risk Assessment Framework: Model Details and Calibration

In MFRAF, the assets for each bank at the start of the year are categorized into illiquid assets (I_0) and liquid assets (M_0).[1] Their liabilities include the stock of various liabilities that may be subject to a run in six months (S_0), other liabilities (L_0), and their common equity Tier 1 (CET1) capital (E_0) (Figure A-1).

In MFRAF, a bank's liquidity characteristics are summarized by its balance-sheet liquidity (λ), which is the ratio of the value of liquid assets (M_0) and illiquid assets (I_0) at the expected fire-sale discount ($\bar{\psi}$) under stress conditions to the stock of liabilities susceptible to a run (S_0) at the interim date:[2]

$$\lambda = \frac{M_0 + \bar{\psi} \times I_0}{S_0}.$$

Figure A-1: Typical bank balance sheet at the start of the year



Source: Bank of Canada

1 For technical details on the model, see Gauthier, He and Souissi (2010) and Anand and Bédard-Pagé (2014).

2 The term $\bar{\psi}$ captures the sentiments of creditors concerning the fire-sale discount that the bank will suffer if it liquidates its portfolio of illiquid assets.

Calibration

Running MFRAF requires a large amount of bank balance-sheet data. For the International Monetary Fund's 2013 Financial Stability Assessment Program (FSAP), MFRAF was used as a "hybrid" to complement the banks' bottom-up stress test. Hence, the data came primarily from the bottom-up stress tests and regulatory returns (Table A-1). The data on interbank exposures used in the network module are from a new regulatory return completed by major Canadian banks.

Running MFRAF also requires calibrating some elements of the model, primarily for the liquidity-risk module.[3] The parameters for the liquidity-risk module were calibrated to be broadly consistent with recently introduced international liquidity standards.[4] Liquid assets include cash holdings and government and other securities that can be pledged as collateral to the liquidity facilities of central banks. Illiquid assets refer to loans to the corporate and household sectors, as well as securities that cannot be pledged to central banks but can be sold for cash in secondary markets (subject to large haircuts calibrated to be consistent with stressed market liquidity conditions). The liabilities that may be subject to a run (S_0) are obtained by aggregating the different funding instruments and maturity profiles, taking into account their respective degrees of stability based on their nature and maturity (e.g., retail deposits are more stable than wholesale funding).

3 The liquidity calibration was agreed upon by Canadian authorities and the International Monetary Fund. To assess the sensitivity of the results to the liquidity calibration, a calibration that was twice as severe was also considered in the FSAP. Under this alternative liquidity calibration, the effects of liquidity risk are more pronounced.

4 For a discussion of the international liquidity standards, see Gomes and Wilkins (2013); for details about the standards, see BCBS (2013).

Table A-1: Data: Sources and calibration

	Variables	Source
Solvency-risk module	EAD, PD, LGD (by economic sectors)[a]	Bottom-up stress test, reported by banks
	Historical covariance matrix of defaults	Bank of Canada internal model
	Operating income	Bottom-up stress test, reported by banks
Liquidity-risk module	Liquid assets (M_0)	Regulatory data
	Illiquid assets (I_0)	Regulatory data
	Fire-sale discounts ($\bar{\psi}$)	Bank of Canada calibration, based on market expertise
	Liabilities subject to a run (S_0)	Regulatory data and Bank of Canada calibration based on international liquidity standards for the inclusion of funding instruments ranked by their stability
Network-effects module	Interbank exposures[b]	Regulatory data
CET1 ratio denominator	Risk-weighted assets	Bottom-up stress test, reported by banks

a. EAD = exposures at default; PD = probability of default; LGD = loss given default

b. All types of interbank exposures were included, after taking into account allowable netting agreements, admissible hedging practices and the value of collateral received. For more information, see OSFI (2013b).

Source: Bank of Canada

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